CHAPTER 3

Criteria Pollutants — Metropolitan Area Trends

http://www.epa.gov/oar/aqtrnd99/chapter3.pdf

Worth Noting:

- Out of 263 metropolitan statistical areas, 34 have significant upward trends.
- Of these, trends with values over the level of the air quality standards involved only 8-hour ozone.

This chapter presents status and trends in criteria pollutants for metropolitan statistical areas (MSAs) in the United States. The MSA status and trends give a local picture of air pollution and can reveal regional patterns of trends. Such information can allow one to gauge the air pollution situation where they live, and can be very useful in formulating plans for community based programs.[1] Not all areas in the country are in MSAs, and not all MSAs are included here. A complete list of MSAs and their boundaries can be found in the Statistical Abstract of the United States.[2] The status and trends of metropolitan areas are based on four tables found in Appendix A (A-15 through A-18). Table A-15 gives the 1999 peak statistics for all MSAs, providing the status of that year. Ten-year trends are shown for the 263 MSAs having data that meet the trends requirements explained in Appendix B. Table A-16 lists these MSAs and reports criteria pollutant trends as "upward" or "downward," or "not significant." These categories are based on a statistical test, known as the Theil test, described later in this chapter.

Another way to assess trends in MSAs is to examine Air Quality Index (AQI) values.[3,4,5] The AQI is used to present daily information, on one or more criteria pollutants in an easily understood format, to the public in a timely manner. Tables A-17 and A-18 list the number of days with AQI values greater than 100 for the nation's 94 largest metropolitan areas (population greater than 500,000). Table A-17 lists AQI values based on all pollutants, while Table A-18 lists AQI values based on ozone alone. The tables listing PSI data from previous reports may not agree with the tables in this report because of the new way to calculate the AQI. These changes are presented in more detail later in this chapter.

Not every MSA appears in these tables. Some do not appear because the population is so small or the air quality is so good that AQI reporting is not presently required. There are MSAs with no ongoing air quality monitoring for one or more of the criteria pollutants, because it is not needed. Ambient monitoring for a particular pollutant may not be conducted if there is no problem. In addition, there are also MSAs with too little monitoring data for trends analysis purposes (see Appendix B).

Status: 1999

The air quality status for MSAs can be found in Table A-15.** Table A-15 lists peak statistics for all criteria pollutants measured in an MSA. As discussed above, not all criteria pollutants are measured in all MSAs. This is why data for some MSAs are designated as "ND" (no data) for those pollutants. Examining Table A-15 shows that 163 areas had peak concentrations exceeding standard levels for at least one criteria pollutant. The number of these areas decreased 6 percent over the count from 1998 data (173 areas). These 163 areas contain 58 percent of the U.S. population. Similarly, there were eight areas (with 8 percent of the population) that had peak statistics that exceeded two or more standards. Only one area, Los Angeles, CA (with 4 percent of the U.S. population), had peak statistics from three pollutants that

**For related information, see Table A-14, peak concentrations for all counties with monitors that reported to the Aerometric Information Retrieval System (AIRS) database.

exceeded the respective standards. There were no areas that violated four or more standards.

Trends Analysis

Table A-16 displays air quality trends for MSAs. The data in this table are average statistics of pollutant concentrations from the subset of ambient monitoring sites that meet the trends criteria explained in Appendix B. A total of 258 MSAs have at least one monitoring site that meets these criteria. As stated previously, not all pollutants are measured in every MSA. From 1990–1999, statistics based on the Standards were calculated for each site and pollutant with available data. Spatial averages were obtained for each of the 263 MSAs by averaging these statistics across all sites in an MSA. This process resulted in one value per MSA per year for each pollutant. Although there are seasonal patterns of high values for some pollutants in some locations, the averages for every MSA and year provide a consistent indicator with which to assess trends.

Since air pollution levels are affected by variations in meteorology, emissions, and day-to-day activities of populations in MSAs, trends in air pollution levels are not always well defined. To assess upward or downward trends, a statistical significance test was applied to these data. An advantage of using the statistical test is the ability to test whether or not the upward or downward trend is real (significant) or just a chance product of year-to-year variation (not significant). Since the underlying pollutant distributions do not meet the usual assumptions required for common significance tests, the test

Table 3-1. Summary of MSA Trend Analyses by Pollutant, 1990–1999

Trend Statistic		Total # MSAs	# MSAs Up	# MSAs Down	# MSAs with No Significant Change
CO	second max 8-hour	138	0	107	31
Lead	max quarterly mean	69	1	44	24
NO_2	arithmetic mean	99	3	41	55
Ozone	fourth max 8-hour	207	25	10	172
Ozone	second daily max 1-hour	207	17	14	176
PM_{10}	90th percentile	216	1	113	102
PM_{10}	weighted annual mean	216	2	126	88
SO_2	arithmetic mean	148	1	86	61
SO_2	second max 24-hour	149	1	82	66

was based upon a nonparametric method commonly referred to as the Theil test.[6,7,8,9] Because linear regression estimates the trend from changes during the entire 10-year period, it is possible to detect an upward or downward trend even when the concentration level of the first year equals the concentration level of the last year.

Table 3-1 summarizes the trend analysis performed on the 263 MSAs. It shows that there were no upward trends in carbon monoxide (CO) for any MSA. Lead, the 90th percentile of PM_{10} and sulfur dioxide had upward trends at only one MSA over the past decade. Further examination of Table A-16 shows that of the 263 MSAs: 1) 214 had downward trends in at least one of the criteria pollutants; 2) 34 had upward trends (of these 34, 26 also had downward trends in other pollutants (leaving 8 MSAs with exclusively upward trends); and 3) 41 MSAs had no significant trends. A closer look at the 34 MSAs with upward trends reveals that most (20) were exceeding the level of the 8-hour ozone standard. For all other pollutants with upward trends in any MSA, the levels observed were well below standard levels. Taken as a whole, these results demonstrate significant improvements in urban air quality over the past decade for the nation.

The Air Quality Index

The AQI provides information on pollutant concentrations for ground-level ozone, particulate matter, carbon monoxide, sulfur dioxide, and nitrogen dioxide. Formerly known as the Pollutant Standards Index (PSI), this nationally uniform air quality index is used by state and local agencies for reporting daily air quality to the public. In 1999, EPA updated the AQI to reflect the latest science on air pollution health effects and to make it more appropriate for use in contemporary news media, thereby enhancing the public's understanding of air pollution across the nation. Currently, the AQI may be found in national media such as *USA Today* and on the Weather Channel, as well as local newspapers and broadcasts across the country. It also serves as a basis for community-based programs that encourage the public to take action to reduce air pollution on days when levels are projected to be of concern. An Internet website, AIRNOW (**http://www.epa.gov/airnow**), which presents "real time" air quality data and forecasts of summertime smog levels for most states, uses the AQI to communicate information about air quality. The Index has been adopted by many other countries (e.g., Mexico, Singapore, and Taiwan) and is used around the world to provide the public with information on air pollutants.

AQI values for each of the pollutants are derived from concentrations of that pollutant. The Index is "normalized" across each pollutant so that, generally, an Index value of 100 is set at the level of the short-term, health-based standard for that pollutant. An Index value of 500 is set at the significant harm level, which represents imminent and substantial endangerment to public health.*** The higher the Index value, the greater the level of air pollution and health risk. To make the AQI as easy to understand as possible, EPA has divided the AQI scale into six general categories that correspond to a different level of health concern. Because different groups of people are sensitive to different pollutants, there are pollutant-specific health effects and cautionary statements for each category in the AQI:

- **Good** (AQI values between 0 and 50) Air quality is considered satisfactory and air pollution poses little or no risk.
- **Moderate** (AQI values between 51 and 100) Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of individuals. For example, people who are unusually sensitive to ozone may experience respiratory symptoms.
- **Unhealthy for Sensitive Groups** (AQI values between 101 and 150) Certain groups of people are particularly sensitive to the harmful effects of certain air pollutants. This means they are likely to be affected at lower levels than the general public. For example, children and adults who are active outdoors and people with respiratory disease are at greater risk from exposure to ozone, while people with heart disease are at greater risk from carbon monoxide. When the AQI is in this range, members of sensitive groups may experience health effects, but the general public is not likely to be affected.
- **Unhealthy** (AQI values between 151 and 200) Everyone may begin to experience health effects. Members of sensitive groups may experience more serious health effects.
- **Very Unhealthy** (AQI values between 201 and 300) Air quality in this range triggers a health alert, meaning everyone may experience more serious health effects.
- **Hazardous** (AQI values over 300) Air quality in this range triggers health warnings of emergency conditions. The entire population is likely to be affected.

An AQI report will contain an Index value, category name, and the pollutant of concern, and is often featured on local television or radio news programs and in newspapers, especially when values are high. For national consistency and ease of understanding, there are specific colors associated with each category that are required if the AQI is reported using color. Examples of the use of color in Index reporting include the color bars that appear in many newspapers, and the color contours of the ozone Map. The six AQI categories, their respective health effects descriptors, colors, index ranges, and corresponding concentration ranges are listed in Table 3-2. The EPA has also developed an AQI logo (Figure 3-1) to increase the awareness of the AQI in such reports and also to indicate that the AQI is uniform throughout the country.

The AQI integrates information on pollutant concentrations across an entire monitoring network into a single number that represents the worst daily air quality experienced in an urban area. For each of the pollutants, concentrations are converted into Index values between zero and 500. The pollutant with the highest Index value is reported as the AQI for that day. There is a new AQI requirement to report any pollutant with an Index value above 100. In addition, when the AQI is above 100 a pollutant-specific statement indicating what specific groups are most at risk must be reported. For example, when the Index is above 100 for ozone the AQI report will contain the statement "Children and people with asthma are the groups most at risk." The AQI must be reported in all MSAs with air quality problems and populations greater than 350,000 according to the 1990 census. Previously, urbanized areas with populations greater than 200,000 were required to report the Index.

***Based on the short-term standards, Federal Episode Criteria, and Significant Harm Levels, the AQI is computed for PM (particulate matter), SO_2, CO, O_3, and NO_2. Lead is the only criteria pollutant not included in the index because it does not have a short-term standard, a Federal Episode Criteria, or a Significant Harm Level.

Table 3-2. AQI Categories, Colors, and Ranges

Category	AQI	O_3 (ppm) 8-hour	O_3 (ppm) 1-hour	$PM_{2.5}$ ($\mu g/m^3$)	PM_{10} ($\mu g/m^3$)	CO (ppm)	SO_2 (ppm)	NO_2 (ppm)
Good	0 – 50	0.000 – 0.064	(2)	0.0 - 15.4	0 – 54	0.0 – 4.4	0.000 – 0.034	([3])
Moderate	51 – 100	0.065 – 0.084	(2)	15.5 – 40.4	55 – 154	4.5 – 9.4	0.035 – 0.144	([3])
Unhealthy for Sensitive Groups	101 – 150	0.085 – 0.104	0.125 – 0.164	40.5 – 65.4	155 – 254	9.5 – 12.4	0.145 – 0.224	([3])
Unhealthy	151 – 200	0.105 – 0.124	0.165 – 0.204	65.5 – 150.4	255 – 354	12.5 – 15.4	0.225 – 0.304	([3])
Very unhealthy	201 – 300	0.125 – 0.374	0.205 – 0.404	150.5 – 250.4	355 – 424	15.5 – 30.4	0.305 – 0.604	0.65 – 1.24
Hazardous	301 – 400 401 – 500	([1]) ([1])	0.405 – 0.504 0.505 – 0.604	250.5 – 350.4 350.5 – 500.4	425 – 504 505 – 604	30.5 – 40.4 40.5 – 50.4	0.605 – 0.804 0.805 – 1.004	1.25 – 1.64 1.65 – 2.04

1. No health effects information for these levels–use 1-hour concentrations.

2. 1-hour concentrations provided for areas where the AQI is based on 1-hour values might be more cautionary.

3. NO_2 has no short-term standard but does have a short-term “alert” level.

Figure 3-1. Air Quality Index logo.

Summary of AQI Analyses

Of the five criteria pollutants used to calculate the AQI, only four (CO, O_3, PM_{10}, and SO_2) generally contribute to the AQI value. Nitrogen dioxide is rarely the highest pollutant measured because it does not have a short-term standard and can only be included when the Index reaches a value of 200 or greater. Ten-year AQI trends are based on daily maximum pollutant concentrations from the subset of ambient monitoring sites that meet the trends requirements in Appendix B.

Since an AQI value greater than 100 indicates that at least one criteria pollutant has reached levels where people in sensitive groups are likely to suffer health effects, the number of days with AQI values greater than 100 provides an indicator of air quality in urban areas. Figure 3-2 shows the trend in the number of days with AQI values greater than 100 summed across the nation’s 94 largest metropolitan areas. This number is expressed as a percentage of the days in the first year (1990). Because of their magnitude, AQI totals for Los Angeles, CA; Riverside, CA; Bakersfield, CA; Ventura CA; Orange County, CA; and San Diego, CA are shown separately as southern California. Plotting these values as a percentage of 1990 values allows two trends of different magnitudes to be compared on the same graph. The long-term air quality improvement in southern California urban areas is evident in this figure. Between 1990 and 1999, the total number of days with AQI values greater than 100 decreased 62 percent in southern California but actually rose 25 percent in the remaining major cities across the United States (see Figure 3-2).

While five criteria pollutants can contribute to the AQI, the index is driven mostly by ozone. AQI estimates depend on the number of pollutants monitored as well as the number of monitoring sites where data are collected. The more pollutants measured and the more sites that are available in an area, the better the estimate of the AQI for a given day. Historically, ozone accounts for the majority of days with AQI values above 100. Soon, $PM_{2.5}$ will also be monitored and reported on a regular basis, which will reduce the percentage of days that ozone is the AQI pollutant. Table A-18 shows the number of days with AQI values greater than 100 that are attributed to ozone alone. Comparing Table A-17 and A-18, the number of days with a AQI above 100 are increasingly due to ozone. In fact, the percentage of days with a AQI above 100 due to ozone have increased from 91 percent in 1990, to 98 percent in 1999 (See Figure 3-3). This increase reveals that ozone increasingly accounts for those days

Figure 3-2. Number of days with AQI values > 100, as a percentage of 1990 value.

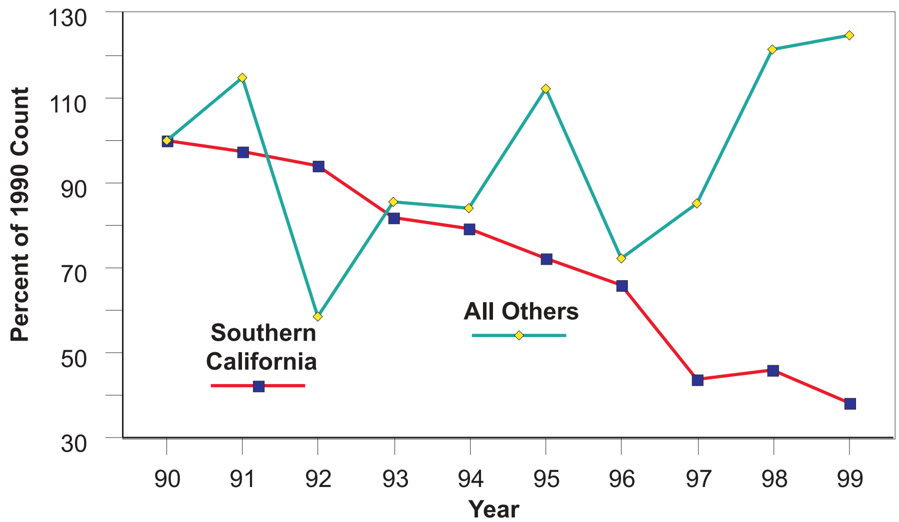
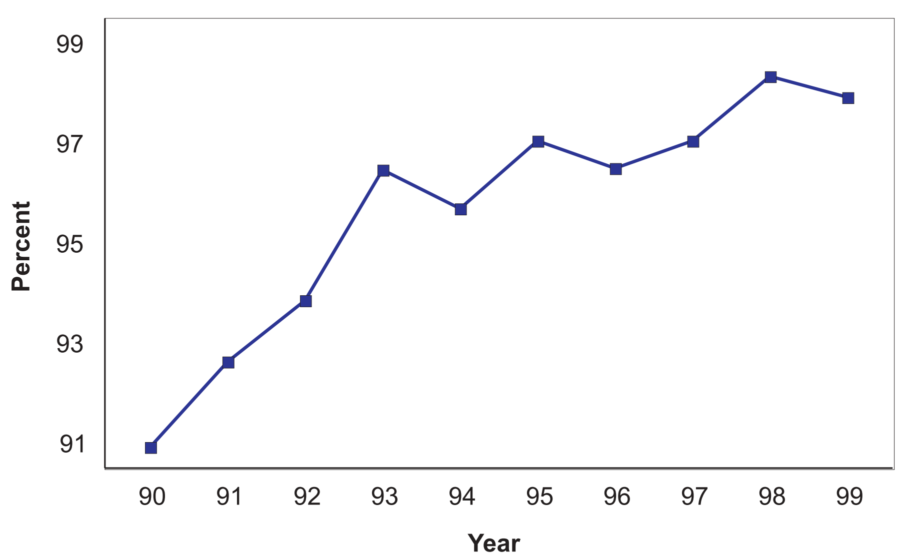


Figure 3-3. Percent of days over 100 due to ozone.



above the 100 level and, therefore, reflects the success in achieving lower CO and PM_{10} concentrations. However, the typical one-in-six day sampling schedule for most PM_{10} sites limits the number of days that PM_{10} can factor into the AQI determination, which may, in some places, account for the predominance of ozone.

References and Notes

1. Community Based Environmental Protection (CBEP) is a relatively new approach to environmental protection. Traditionally, environmental protection programs have focused on a particular medium or problem (i.e., a "Command and Control" approach to environmental protection). These "Command and Control" programs have been very effective at reducing point source pollution and improving environmental quality for more than two decades. However, some environmental problems, such as non-point source pollution, which may involve several media types and diffuse sources, are less amenable to the "Command and Control" approach. Instead, a solution that seeks to address the various causes of the problems by focusing on the interrelationships between human behavior and pollution in a specific area may be more appropriate. CBEP supplements and complements the traditional environmental protection approach by focusing on the health of an ecosystem and the behavior of humans that live in the ecosystem's boundaries, instead of concentrating on a medium or particular problem. Therefore, CBEP is place-based, and not media or issue-based (see **http://www.epa.gov/ecocommunity/about.htm**).

2. *Statistical Abstracts of the United States, 1999*, U.S. Department of Commerce, U.S. Bureau of the Census.

3. *Air Quality Index, A Guide to Air Quality and Your Health*, EPA-454/R-00-005, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, June 2000.

4. *Code of Federal Regulations*, 40 CFR Part 58, Appendix G.

5. *Guideline for Reporting of Daily Air Quality—Air Quality Index* (AQI), EPA-454/R-99-010, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, July 1999.

6. *Note:* Although the results are summarized in the report for comparison purposes, the intent of publishing Tables A-16 through A-18 is to present information on a localized basis, to be used on a localized basis (i.e., one MSA at a time). Therefore, no attempt was made to adjust the Type I error to a table-wide basis. All the tests for trends were conducted at the 5-percent significance level. No inference has been made from the tables as a whole.

7. T. Fitz-Simons and D. Mintz, "Assessing Environmental Trends with Nonparametric Regression in the SAS Data Step," American Statistical Association 1995 Winter Conference, Raleigh, NC, January, 1995.

8. Freas, W.P. and E.A. Sieurin, "A Nonparametric Calibration Procedure for Multi-Source Urban Air Pollution Dispersion Models," presented at the Fifth Conference on Probability and Statistics in Atmospheric Sciences, American Meteorological Society, Las Vegas, NV, November 1977.

9. M. Hollander and D.A. Wolfe, *Nonparametric Statistical Methods*, John Wiley and Sons, Inc., New York, NY, 1973.